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Food and Nutrition Security Potential of Finger Millet in Ethiopia

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Despite remarkable achievements in the sector, the problem of food and nutrition security remains a key main health and development issue in Ethiopia, and food production to meet future demand of the growing population requires expansion of the farming land, intensification of the current production and use of harsh tolerant crops. Despite its high nutritional profile, good tolerance to adverse conditions and significant role in household nutrition, finger millet received little attention. This review summarized the potential of finger millet as a sustainable food source to Ethiopian community. The review has shown that finger millet is rich in macro and micro nutrients indicating the crop has potential to enhance household food and nutrition security in the country. The high dietary fiber, minerals and phytochemical contents together with gluten free nature of finger millet makes a recognized functional food. Nutrition information on the crop in general is limited. Even the improved finger millet varieties are mainly based on agronomic traits such as yield and disease resistance. Therefore the breeding research shall give prior attention to nutritional quality parameters. Processing finger millet can improve nutritional quality, sensory acceptability, and more importantly decrease inhibitors thereby enhance bioavailability of nutrients. However, most of such information are lacking at consumer level and needs awareness creation. Moreover, use of finger millet as an ingredient of composite flours to prepare different food products could be a good approach to promote utilization of the crop in urban areas of the country.

Key words: Finger millet, food security, nutrition security, health benefits, processing, Ethiopia

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INTRODUCTION

Despite remarkable achievements in the sector, the problem of food and nutrition security remains a key main health and development issue in Ethiopia. With 38% of children less than five years stunted, 10% wasted and 21% of the total population undernourished, the country has one of the highest levels of chronic undernutrition in the world (FAO, 2018). Ethiopia is also experiencing a diverse climate change whereby several parts of the country are suffering from drought, unreliable rainfall patterns and soil erosions (Mohamed, 2017; FAO, 2018; Dessi, 2018). Drought, shortage of farm land, soil erosion, poor soil fertility, frost and poor farming technologies are reported to be the major problems deteriorating food security situation in the country (Endalew et al., 2015). On the other hand, population of the country is estimated to rise from 107.5 to 190.9 million between 2018 and 2050 (Population Reference Bureau, 2018). Thus, food production to meet future demand requires expansion of the farming land, intensification of the current production and use of harsh tolerant crops to ensure sustainable food availability at house hold level.

Being major food sources for low income households and grown in hot and dry areas, it is important to explore millets in places like Ethiopia. Millets are known to play a significant role in agriculture and food security system for millions of poor farmers in Sub-Saharan Africa and other less developed countries in the world (Amadou et al., 2013; Bora, 2013). Resistance to pests and diseases, adaption to a wide range of environment, good production yield, short growing season, little input requirement, withstanding significant salinity and water logging tolerance of millets make them important crops for future human use (Chandra et al., 2016). Globally, it has been reported that millets are the sixth most important cereal and feeds one third of the total population (Saleh et al., 2013; Bora 2013). Millets are also nutritious and have various health benefits (Bora, 2013; Amadou et al., 2013; Rathore et al., 2016; Shivananjappa, 2018). Proso millet *(Panicum miliaceum)*, Foxtail millet *(Setaria italica)*, Japanese barnyard millet *(Echinochloa frumentacea)*, Finger millet *(Eleusine coracana)* and Koda millet *(Paspalum scrobiculatum)* are the most important cultivated species (Singh and Raghuvanshi, 2012).

Finger millet, also called d*agussa* in Ethiopia, is one of the neglected and underutilized crops in Africa and India. It is native to Ethiopian highlands and plays a crucial role in dietary needs and income sources for many rural households of the country (Admassu et al., 2009; Ayalew, 2015; Tesfaye and Mengistu, 2017; Zewdu et al., 2018). Finger millet accounts about 4% of the total area allocated to cereals and the sixth important crop in the country after tef, wheat, maize, sorghum and barley (CSA, 2018). Covering 12% of the total millet area in the world, finger millet is cultivated in more than 25 countries of Africa and Asia (Bora, 2013; Kumar et al., 2016). About 55-60% of the total finger millet is produced in Africa and forms a predominant staple food for people living on marginal lands and with limited economic resources (Kumar et al., 2016; Ramashia et al., 2019).

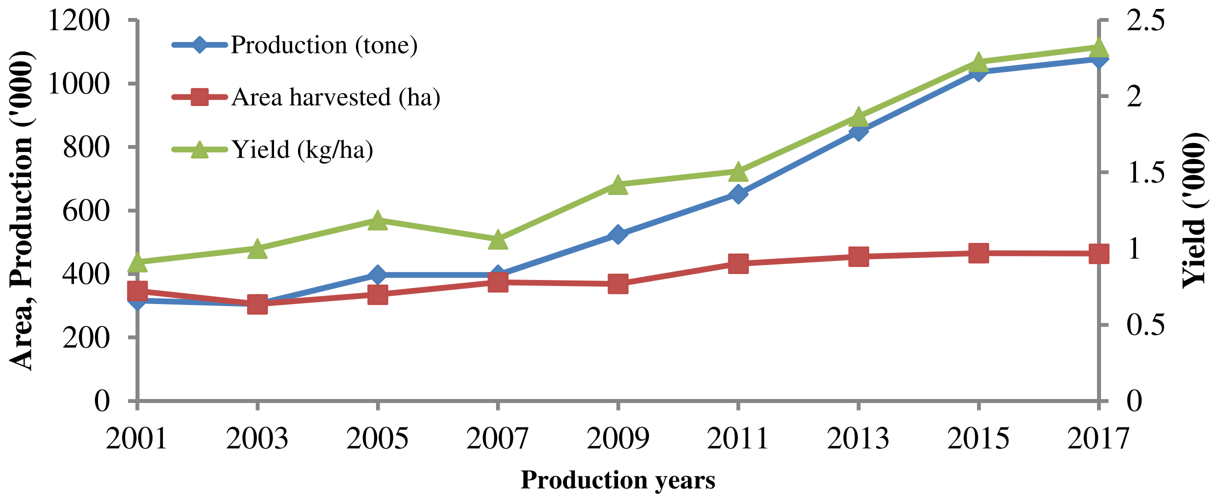
In nutrition perspectives, nutrient density of finger millet is higher than major cereals such as wheat and rice. The crop is considerably rich in minerals, fiber, essential amino acids, unsaturated fatty acids and vitamins (Antony and Chandra, 1998; Vadivoo et al., 1998). For example, calcium content in finger millet is 10 times higher than brown rice, wheat or maize and three times greater than milk (Kumar et al., 2016). In addition, low glycemic index and gluten free nature of finger millet grains represent as an ideal food for peoples with celiac disease and diabetes (Muthamilarasan et al., 2016; Ramashia et al., 2019). Finger millet is consumed in different forms as food and the residue serves as livestock feed, fuel, and to make hats in rural areas of the country.

Though finger millet has high nutritional profile, good tolerance for adverse growing conditions and significant role in household nutrition, there is little research and government attention in Ethiopia as compared to other common cereals such as tef, maize, wheat, barley, sorghum and rice. With the growing demand for small grain in the world, it is a potential innovative and economically promising export crop for the country in addition to contributing food and nutrition security. Therefore, this review summarizes the potential of finger millet as a sustainable food source to Ethiopian community. It provides a brief overview of production status, nutritional quality, health benefits, processing and application of finger millet.

PRODUCTION AND IMPROVED VARIETIES

Due to its wide range of altitudes, temperature extremes, different soil types and huge amounts of annual rainfall, Ethiopia is known for rich biodiversity and center of origins for many crops, including finger millet (Tesfaye and Mengistu, 2017). Finger millet is grown in Tigray, Amhara, Oromiya, Benishangul-Gumuz, Southern Nation and Nationalities Peoples (SNNP) and Gambela regional states of Ethiopia (Admassu et al., 2009; Tesfaye and Mengistu, 2017), as a dietary staple food crops mainly in drought-exposed parts of the regions. A recent figure of CSA (2018) showed that in 2017 *meher* season 1,765,40 private peasant holders have cultivated finger millet on about 456,057 ha of land and produced about 1,030,823 tons.

Published sources indicated that productivity of finger millet in the country generally is low because of shortage of improved varieties, disease and pests, poor application of seed and fertilizer, moisture stress in dry areas and little research concern given to the crop (Ayalew, 2015; Tesfaye and Mengistu, 2017; Zewdu et al., 2018). Between 2001 and 2017 finger millet production area in Ethiopia increased from 346,780 to 463,992 ha with an increase of 33.8%, and the total production in the same duration increased from 316,166 to 1,077,616 tones which is more than a threefold increment (Figure 1). Similarly, 912 kg/ha yield of finger millet at 2001 increased to 2,323 kg/ha at 2017. According to Ayalew (2015), the release of finger millet varieties in the country is the most important factor for the improvement of yield in 2000s. The author indicated that yield of finger millet in Ethiopia increased by 66% over the past three decades. Fourteen finger millet varieties are released between 1999 and 2015 (Table 1). Dissemination of new improved varieties, training and demonstration of management packages are key strategies recommended by different authors to improve productivity of finger millet in Ethiopia (Tefera and Adane, 2013; Zewdu et al., 2018).



Source: Calculated based on FAOSTAT: Accessed on May 20, 2019
Figure 1. Production trend and yield of finger millet in Ethiopia

Table 1. Improved finger millet varieties in Ethiopia

No	Variety	Year of release	Adaptation area		Seed color	Height (cm)	Days to maturity	Yield qt/ha	
			Altitude (m.a.s.l)	Rainfall (mm)				Research field	Farmers field
1	Kako-I (LR005)	2015	1310 - 1700	>900	Brown to white	69-76	139	26-29	16-20
2	Tessema (ACC#229469)	2014	1600 - 1900	>900	Brown	95	145-150	18-22	14-18
3	Gudeta (Acc.215990)	2014	1400-1900	200-1300	Light brown	92	145-150	21-23	20-21
4	Mecha (Acc # 229371)	2014	1900-2500	>900	Red brown	80-93	140-154	20-29	16-23
5	Necho (PGRC/E203572)	2011	1900-2500	>900	White	85-101	145-175	20-30	15-20
6	Debatsi	2010	1100-1600	1000-1800	Brown	74	155-167	20-25	15-20
7	Bareda (BRC-356-1)	2009	1200-1900	1000-1200	Brown	81-97	146-169	20-28	18-25
8	Gute (229373)	2009	1200-1900	1000-1200	Brown	96	140-153	20-35	20-32
9	Wama (KNE#392)	2007	1400-1900	1000-1200	Brown	80-185	145-150	17-35	16-30
10	Baruda (Pw01-075)	2007	1000-1500	700-1500	Red	80-123	149-159	30-35	-
11	Degu (PGRC/E 215874)	2005	1900-2500	>900	Light	93	137-160	23-30	17-21
12	Boneya (KNE#411)	2002	1400-1900	1200-1300	Red	70-90	145	25-30	20-24
13	Padet (KNE #409)	1999	1600-1900	>700	Brown	94	-	24	-
14	Tadesse (KNE #1098)	1999	1600-1900	>700	Brown	96	-	25	-

Source: Crop Variety register 2016, 2014, 2011, 2010, 2009, 2007, 2005, 2002, 1999

NUTRITIONAL COMPOSITION

Carbohydrate

Containing 72.6 - 85.6 g/100g of the grain, carbohydrate is the first major component of finger millet (Table 2). Singh and Raghuvanshi (2012) reported a carbohydrate content of the same crop in the range of 72 to 80 g/100g. Starch, is the most important carbohydrate in all grains, provides physiological energy in the human diet. The content of starch in finger millet ranges from 59.4 to 70.2% of dry matter, of which 80 - 85% is amylopectin and the remaining 15 - 20% is amylose (Nirmala et al., 2000). About 20 - 30 g/100g of carbohydrate in finger millet is non-starch polysaccharide (Singh and Raghuvanshi, 2012). The crop also contains about 1.5% and 0.03% of reducing and non-reducing sugar, respectively (Nirmala et al., 2000).

Fiber

Fiber is the carbohydrate fraction resistant to enzymatic digestion and absorption in the small intestine, and undergoes full or partial fermentation in the large intestine (Graf et al., 2014). Comprising about 2.0 - 3.6% of the total weight of the grain, finger millet noted as a good source of crude fiber (Table 2). According to Amadou et al. (2013), total dietary fiber of finger millet (22.0%) is higher than wheat (12.6%), rice (4.8%) and maize (12.8%) grains. Studies showed that high consumption of fiber-rich whole grains is associated with a lower risk of type II diabetes and cardiovascular disease (Gordillo-Bastidas et al., 2016**).** Dietary fiber is also reported to have several functional properties including optimal digestive health, promote satiety, reduce cholesterol and lipid absorption, modulate postprandial insulin response and reduce risk and severity of gastrointestinal infection and inflammation (Graf et al., 2014).

Table 2. Proximate composition of finger millet grain (g/100g)

Proximate	Amadou et al 2013	Jaybhaye et al 2014	David et al 2014	Chandra et al 2016	Lansakara et al 2016	Katake et al 2016	Ramashia et al 2019	Average
Protein	8.2	7.7	10.3	7.3	6.5	5.9	7.7	**7.6**
Fat	1.8	1.5	0.8	1.3	1.3	1.8	1.8	**1.5**
Fiber	3.5	3.6	3.1	3.6	3.4	2.0	-	**3.2**
Minerals	2.7	2.6	2.4	3.0	2.0	2.5	2.7	**2.6**
Carbohydrate	83.3	72.6	76.4	72.6	85.6	75.3	79.0	**77.8**
Energy*	382.2	334.7	354.3	331.3	380.0	341.1	363.0	**355.2**

*Energy (kcal/100 g) = [9 × fat (%) + 4 × protein (%) + 4 × carbohydrates (%)]

Protein

Protein content of finger millet is in general ranges between 5.9 and 10.3 g/100g with an average content of 7.6 g/100g (Table 2). A larger variation of 5.6 - 12.7% of protein content is reported by Singh and Raghuvanshi (2012). Admassu et al. (2009) also analyzed 9 finger millet varieties in Ethiopia and reported a protein content range of 6.26 - 10.50 g/100g. An investigation done using 36 genotypes of finger millet showed that protein contents of brown seeded grains were higher than white types (Vadivoo et al., 1998). Consisting 25 to 36% of the total protein, prolamin fraction is the major storage protein of finger millet (Jaybhaye et al., 2014). Digestibility of protein is another important quality parameters that can positively correlate with the proportion of protein absorbed from a food. In this regard, digestibility of finger millet ranges between 50 - 88% (Singh and Raghuvanshi, 2012).

From nutritional point of view, essential amino acids are the most important aspect of a protein as they have carbon skeletons that cannot be synthesized by humans and must be provided through the diet (Mota et al., 2016). Finger millet grain contains all the nine essential amino acids and their content level from largest to smallest can be ordered as leucine, valine, isoleucine, phenylalanine, thereonine, methionin, lysine, histidine and tryptophan (Table 3). According to FAO (1991) scoring pattern, except lysine all other essential amino acids in finger millet are adequate for children 2 to 5 years old. Tryptophan and threonine which are deficient in cereals such as rice, wheat and sorghum are not deficient in finger millet (FAO, 1968). Compared to other millet species, finger millet contains higher amount of methionine (Ramashia et al., 2019), lysine, threonine and valine (Singh and Raghuvanshi, 2012). In general the crop contains a good ratio of essential amino acids to total amino acids with a proportion of 45% (Jaybhaye et al., 2014), and this value is greater than the 34% essential amino acids in FAO reference protein (FAO, 1991). Thus, finger millet could be a good alternative for protein source especially in rural areas where animal source foods and nutritionally improved food products are out of the reach of most Ethiopian families.

Table 3. Essential amino acids content of finger millet grain (mg/100g)

Amino acid	Chandra et al 2016 (mg/100g)	Amadou et al 2013 (mg/100g)	Ramashia et al 2019 (g/100g protein)
Histidine	130	230	2.2
Isoleucine	400	430	4.3
Leucine	690	1080	6.6-9.5
Lysine	220	220	2.2
Methionine	210	290	2.5-3.1
Phenylalanine	310	600	4.1-5.2
Threonine	240	430	3.4-4.2
Tryptophan	100	-	1.1-1.5
Valine	480	630	4.9-6.6

Fat

Unlike other millets which contain a fat proportion of 4-5% (Ramashia et al., 2019), level of fat in finger millet is usually less than two percent (Table 2). This low fat content together with high dietary fiber contributes for functional properties of the crop. Fat is a concentrated source of energy and structural components of cell membranes to function our body normally, and quality is very important. In this regard, finger millet shown to contain high unsaturated fatty acids (about 74% of the total fatty acids) including oleic acid, palmitic acid and linoleic acid (Singh and Raghuvanshi, 2012).

Minerals and vitamins

Minerals are essential to regulate electrolyte balance, glucose homeostasis, transmission of nerve impulses and enzyme cofactors in our body. Total mineral (ash) content of finger millet is higher than most commonly consumed cereals (Singh and Raghuvanshi, 2012), and the proportion is generally between 2 - 3% (Table 2). According to a nutritional comparison by Agza et al. (2017), common cereals in Ethiopia such as tef, maize, wheat, barley, sorghum and rice contains a total mineral proportion of 2.8, 1.7, 1.6, 3.1, 1.7 and 1.4% respectively. Calcium, phosphorous, magnesium, iron, zinc, potassium and manganese contents of finger millet grain are presented in Table 4. The crop is particularly rich in essential minerals, calcium and iron (Admassu et al., 2009; 2012; Chandra et al., 2016; Ramashia et al., 2019). FAO (2018) indicated that prevalence of anemia among Ethiopian women of reproductive age increased from 21.7% at 2012 to 23.4% at 2016. Thus anemia caused by iron deficiency and bone disorder caused by calcium deficiency can be overcome by including finger millet in common food basket.

Vitamins which are other nutrients in finger millet are essential for human health particularly to regulate cell growth and development, to improve vision, to act as enzymatic cofactors in metabolism, as an antioxidant and other physiological processes. Both fat and water-soluble vitamins are reported to be available in finger millet grains, and rich in vitamins A and B complex (Chappalwar et al., 2013; Ramashia et al., 2019). Therefore, being rich in minerals and consisting significant amount of vitamins, finger millet can be a potential crop in Ethiopia to fight hidden hunger in a sustainable way particularly to children, pregnant and lactating women, and other vulnerable groups.

Table 4. Minerals content of finger millet grain (mg/100g)

Minerals	Admassu et al 2009	Chandra et al 2016	Hiremath et al 2018	Ramashia et al 2019	Average
Calcium	257	344	282	398	320.3
Phosphorous	122	283	228	190 (130-250)	205.8
Magnesium	168	137	166	140 (78-201)	152.8
Iron	27*	3.6	3	9.1 (3.3-14.9)	5.2
Zinc	1.8	2.3	2.79	2.3	2.3
Potassium	-	408	-	460 (430-490)	434.0
Manganese	28.35	5.49*	25	33 (17.6-48.4)	23.0

*Not included in the calculation of average

HEALTH BENEFITS

Finger millet is not only a nutritious diet but also has essential health benefits that makes the crop a source of functional and nutraceutical foods. The health importance of finger millet is related to its high content of dietary fiber, minerals, phytochemicals, and low glycemic index and gluten free nature of the crop (Amadou et al., 2013; Bora, 2013; Kumar et al., 2016; Chandra et al., 2016; Rathore et al., 2016; Xiang et al., 2018). This outstanding composition makes finger millet an effective food against cancer, type II diabetes, heart attack (strokes), celiac disease, anemia, allergy, constipation and gastro-intestinal disorders (Bora, 2013; Rathore et al., 2016; Ramashia et al., 2019). Kandel et al. (2019) showed that finger millet is believed to be a good diet for pregnant women and for treatment of animal diarrhea. The author also indicated that in Vietnam the crop used as medicine for women when they give birth and in south India pediatricians recommend finger millet based foods for infants above six months.

The phenolic compounds, dietary fiber, minerals and vitamins concentrated mainly in the seed coat of finger millet (Chandra et al., 2016; Kumar et al., 2016**).** Studies indicated that phenolic content and antioxidant activity of finger millet is vary with the color of the seed. Chethan and Malleshi (2007) reported a poly phenol content of 0.08-3.47% for brown varieties and 0.04-0.09% for white varieties. A study by Xiang et al. (2018) also indicated that colored (brown, red or reddish) seeded finger millet grains have higher levels of phenolic compounds than white types. The phytochemicals and antioxidants of finger millet act as terminators of free radicals and suppress excessive cellular oxidation preventing heart attack and certain types of cancer in human (Kumar et al., 2016).

Low glycemic index of finger millet which exhibited by slow release of glucose into the blood stream during digestion is correlated with lowering the risk of diabetes (Chappalwar et al., 2013; Ramashia et al., 2019). Studies also indicated that the ability of finger millet to alleviate type-II diabetes indirectly connected to the high content of calcium and magnesium in the crop helping to control blood glucose level (Kumar et al., 2016). Moreover, the insoluble dietary fibers in finger millet are resistant to break down during digestion and bulk the stool, acts as laxative for stimulating bowel mobility and retain water where the phenomena prevents constipation, gastro-intestinal disorders, colon cancers and heart diseases (Kumar et al., 2016). Gluten free nature of the crop is another advantage to substitute cereals such as wheat. Gluten is a major cause of celiac disease and such patients should consume gluten free grains, where finger millet is a good option (Saleh et al., 2013, Amadou et al., 2013; Rathore et al., 2016).

ANTINUTRIENTS

Antinutritinal components decrease the bioavailability of minerals in cereals and legumes (Rathore et al., 2016), and phytic acids and tannins are the main inhibitors in finger millet (Singh and Raghuvanshi, 2012; Palanisamy et al., 2012; Ramashia et al., 2019). Phytic acid is the major storage form of phosphorous in mature seeds and when it binds to a mineral known as phytate. If a food contains high phytic acid, the acids bind minerals and render them unavailable for metabolism **(**Gordillo-Bastidas et al., 2016). Antony and Chandra (1999) and Rao (1994) estimated phytate content of finger millet in the range of 679-693 and 149-150 mg/100g respectively. Literatures, however, indicated that phytate content significantly reduced by using different food processing techniques including soaking, malting, germination, fermentation and their combinations. Agte and Joshi (1997) reported that soaking cereal grain before heating activated phytase enzymes and improved availability of the mineral zinc. Rao (1994) also reported malting reduced phytin phosphorus content by 58-65% in different finger millet varieties. There is also a report on germination and fermentation effect in finger millet where they reduced phytic acid level by 49% and 67% respectively (Mammiro et al., 2001).

Tannins are other major antinutrients abundantly available in finger millet. The tannin level in finger millet is between 0.04 to 3.74%, and with this amount the crop contains higher tannins than other millets (Rao, 1994; Antony and Chandra, 1999; Singh and Raghuvanshi, 2012). Tannins, the other major antinutrient in finger millet, bind to proteins including enzymes that play roles in digestion and reduce utilization of proteins. There is also a report that indicate about half of the iron in our diet might be bound to tannins (Rao and Prabhavati, 1982). Similar to phytic acid, processing methods such as soaking, roasting, boiling, germination and fermentation can potentially reduce tannin level in finger millet based foods (Rao and Prabhavathi, 1982; Rao, 1994).

PROCESSING

Grain processing is a series of mechanical or chemical operations to convert the grain into edible form and thereby improving its nutritional quality, sensory acceptability and physical property**.** Many food processing methods are also reported to enhance bioaccessability and bioavailability of nutrients in plant based diets by reducing antinutrients. The different processing techniques of finger millet include decortications, milling, malting, fermentation, soaking, cooking, roasting, popping and extrusion (Saleh et al., 2013; Amadou et al., 2013; Rathore et al., 2016; Ramashia et al., 2019). Common processing methods with their purpose are briefly discussed below.

Decortication

Decortication is removal of pericarp from cereal grains. Traditionally, the primary target of decortication is to enhance color, texture and cooking quality of grains. The process removes about 12-30% of the outer surface of the grain where most inhibitors are concentrated but excess decortication lead to the loss of nutrients including dietary fiber, minerals and fat (Rathore et al., 2016). Thus the technique in general needs an efficient and advanced technology that can only remove the outer surface of the grain containing much phytic acid without or minimal loss of important nutrients. Studies indicate that appropriate decortication significantly reduce phytic acid and tannin levels in finger millet and as a result increase the bioaccessibility of calcium (15%), iron (26%) and zinc (24%) (Jaybhaye et al., 2014).

Milling

Milling of cereal grain is an important operation performed to reduce particle size and obtain flour. During milling, the fibrous bran, tannins and phytic acids removed and the action reported to decrease the total nutrient content and improve their bioavailability (Singh and Raghuvanshi, 2012). Milling also results the damage of some starch and this damage increase water binding capacity of the flour but excessive damage reduce bread quality (Deosthale, 2002). In Ethiopia finger millet is milled by tef miller which is dry milling and using Danish type stone mill/ disc mill.

Malting

Rathore et al. (2016) defined malting as "limited germination under moist controlled conditions of cereals". Ramashia et al. (2019) also expressed malting as "a combined process of steeping, germination, drying, toasting, grinding and sieving in order to achieve high nutritional quality, better starch digestibility, sensory properties and reduced antinutritional activities". Malting of finger millet is a common technology used in Africa and India as malted finger millet is superior to malted maize and sorghum (Sarkar et al., 2015; Ramashia et al., 2019). In comparison to sorghum and other millets, the crop reported to develop higher amylase activities (Singh and Raghuvanshi, 2012). According to literatures, malting can enhance sugar and essential amino acid contents of finger millet. Shukla et al. (1986) reported an increase of total sugars from 1.5 to 16.0% and reducing sugar from 1.4 to 8.4% because of malting. Malleshi and Desikachar (1986) compared lysine and tryptophan content of raw and malted finger millet and they reported an increase of 14 and 15% respectively. During malting, the seed coat of grain is removed and the action reduces mineral contents while improving their bioavailability. There is a report that indicate a decrease of calcium (32%), phosphorous (26%) and iron (33%) due to malting (Hemanalini et al., 1980). On the other hand, malting shown to reduce tannin and phytin phosphorous level in brown varieties of finger millet by 54 and 58%, respectively (Rao, 1994).

Fermentation

Fermentation is a processing method used to preserve different food products and improve their nutritional and sensory qualities by using microorganisms. It can be initiated by adding starter culture collected from previous batch of fermentation or spontaneously without any addition of microorganisms. The byproducts (acids/antibiotics) produced by breakdown of starch by microorganism during fermentation process inhibits pathogenic and spoilage microorganisms (Ramashia et al., 2019). Improvement of flavor, reduction of antinutrients, increase in nutritional quality of foods are some of the changes take place during fermentation (Singh and Raghuvanshi, 2012; Rathore et al., 2016). Nutritional enhancement of cereal fermentation is highly related with its improvement in bioavilability of nutrients. Rathore et al. (2016) indicated that reduction of anti-nutrients and improvement of mineral bioavailability increased with increasing fermentation time. Quantitatively, fermentation of finger millet decreased phytates, tannins and trypsin inhibitor activities by 20, 52 and 32% respectively (Antony and Chandra, 1998). Hamad and Fields (1979) reported 18 and 7% increment of tryptophan and lysine contents due to fermentation of finger millet. According to a review by Singh and Raghuvanshi (2012), fermentation of finger millet can also enhance protein biological value, thiamin, roboflavin and niacin contents. Most traditionally processed finger millet based foods and beverages involve fermentation steps and currently the process upgraded to be used in food industries commercially (Ramashia et al., 2019).

USE AND APPLICATION

Finger millet has traditional and commercial applications in different part of the world. Traditionally, grain of finger millet used to prepare alcoholic and nonalcoholic beverages while its flour is utilized as different food products such as porridge and bread (Ramashia et al., 2019). Commercially, different applications have been investigated to use finger millet grain as composite flour, bakery products, extruded products and other gluten free cereal based foods (Rathore et al., 2016). Finger millet based food products are generally vary from country to country and region to region, and most products developed in developing countries are not commercialized (Towo et al., 2006; Ramashia et al., 2019). Commercially available and popularly consumed finger millet based products in developed country include spaghetti, macaroni, pasta, noodles, vermicelli and flakes (Jaybhaye, 2014). In the manufacturing of extruded snacks the crop is used together with buck wheat and amaranth in place of maize and wheat (Rathore et al., 2016). In Ethiopia, finger millet is used for making *injera,* local beverages, porridge, bread, soup, traditional breakfast called *chechebsa*, and the straw used as forage for animals (Zewdu et al., 2018). *Injera,* fermented pancake-like, soft, circular flat bread, could be prepared alone or mixed with tef (*Eragrostis tef*) which is best crop for making *injera*. *Tella* and *Areki* are Ethiopian traditional beverages which are prepared from different cereals including finger millet. Hailu and Gebreyohans (2017) from north Ethiopia recommended mango flavored finger millet juice. According to the authors the juice can be an excellent alternative to get all the nutritional benefits of the crop. Unavailability of value-added convenient finger millet based food products limited consumption of the crop in urban areas of Ethiopia.

CONCLUSIONS AND RECOMMENDATIONS

This review has shown that finger millet is rich in macro and micro nutrients making the crop an important ingredient of dietary and nutritional balanced foods. This in turn shows that the crop has potential to enhance household food and nutrition security for the growing population of Ethiopia where energy-protein malnutrition affects a greater part of the country. Being rich in minerals and consisting significant amount of vitamins, finger millet can also be a potential crop to fight hidden hunger. Moreover, as the crop is high in dietary fiber content, minerals, phytochemicals, and low in glycemic index and gluten free in nature, finger millet based products has been considered as functional foods. In comparison to other cereals, finger millet research received little attention and particularly nutrition information on the crop is limited. Even the improved finger millet varieties are mainly based on agronomic traits such as yield and disease resistance. Therefore the breeding research shall give prior attention to nutritional quality parameters. Processing practices of finger millet have essential roles in improving nutritional quality, sensory acceptability, and more importantly decreasing inhibitors such as phytate and tannins thereby enhancing bioavailability of nutrients. However, such information are usually lacking at consumer level and needs awareness creation. Moreover, use of finger millet as an ingredient of composite flours to prepare different food products/recipes such as *injera*, bread, porridge, biscuits and cookies could be a good approach to promote utilization of the crop in urban areas of the country.

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